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The second mesiobuccal canal in three-rooted maxillary first molar of Karnataka Indian sub-populations: A cone-beam computed tomography study

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ABSTRACT

Introduction: Elusive second mesiobuccal canal (MB2) in maxillary first molar are often missed during endodontic therapy and are a major cause of treatment failures. Its prevalence is known to vary among different populations and there is limited information on its prevalence in Indian population.
Aim: This study investigated the prevalence and location of second mesiobuccal (MB2) canal in mesiobuccal root of maxillary first molar using cone beam computed tomography (CBCT) images in an Indian population.
Materials and methods: CBCT images of 598 three rooted maxillary first molars were studied. In each CBCT image, the floor of pulp chamber was located and advanced by 2 mm to standardize the observation for MB2 canal. Its location was determined in relation to mesiobuccal (MB1) and palatal (P) canal.
Statistical analysis: The data was analysed using descriptive statistics. The presence of MB2 canal was correlated with age, gender and tooth position using Chi square test.
Results: The prevalence of MB2 canal in three rooted maxillary first molar was 61.9%. It was seen that the prevalence of MB2 was highest in 20–40years age group (67.4%) followed by > 40 years (57.5%) and lowest in < 20 years (50.6%) and the difference was statistically significant ($p = 0.005$). It is located mesiopalatally; 2.5 mm ± 0.6 mm palatally and 1.0 ± 0.4mmmesially to the MB1 canal or present directly on the line joining the MB1 and palatal canal.
Conclusion: There is a high probability of finding MB2 canal in Indian patients. The access cavity must be modified from a triangular shape to rhomboid shape. Troughingmesiopaltally (about 2.5 mm palatally and 1 mm mesially) from MB1 to a depth of about 2 mm from the floor of pulp chamber may be necessary for locating MB2 canal.

1. Introduction

Thorough and intricate knowledge of the root canal anatomy of teeth plays a pivotal role in endodontic treatment. This is essentially true in teeth that exhibit complexities and variations in their internal morphology like the maxillary molars. Maxillary first molar are one of the first teeth to erupt into the oral cavity and hence, is one of the most commonly treated teeth. They possess the largest pulp volume and have greatest number of roots (mesiobuccal, distobuccal and palatal roots) with each root exhibiting variations in size, shape, form and internal anatomy. However, mesiobuccal root shows the maximum variations.[1]

They also constitute 20% of all the teeth that require non surgical endodontic re-treatment.[2] According to Witherspoon DE (2013), 44% of retreatment in maxillary first molars is due to missed canals and 93% of these missed canals are identified in the mesiobuccal root.[3] These missed canals in mesiobuccal roots are frequently a second mesiobuccal canal (MB2/Mesiopalatal canal), whose occurrence may be attributed to the wide bucco-palatal dimensions of the mesiobuccal root. These emphasizes that failure to locate, debride and obturate this canal can be a threat to success of endodontic therapy in maxillary first molar.[3]

Wide variations exists in literature on prevalence and location of MB2 canal in maxillary first molar due to ethnic variations, design and

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method of study and author's definition of what constitues a canal.[4] A number of in vivo (periapical radiography, clinical evaluation during root canal therapy, dental operating microscopes, dental operating microscopes with ultrasonics, etc) and in vitro [clearing, sectioning of teeth, Cone Beam Computed Tomography (CBCT) and micro-CT] techniques have been applied in studying the morphology of mesiobuccal root and assessing its root canal anatomy.[5–7]

Limited studies to describe the prevalence and location of MB2 canal in maxillary first molar of Indian population are present in literature. Hence, aim of this study was to investigate the prevalence and location of MB2 canal in mesiobuccal root of maxillary first molar of Indian population using CBCT.

2. Materials and methods

A total of 310 CBCT scans of maxilla taken between 2016–July 2018 of Indian population residing in Karnataka were obtained from a CBCT diagnostic center and were studied retrospectively. These scans were of 189 males and 121 females. Ethical clearance was obtained from Institutional review committee of VS Dental college, Bangalore. The data for this study was acquired from scanning performed using the same CBCT scanner (KODAK 9300). The scanning parameters were 90-100 kVp, 4–6 mA, for 6 or 8 or 11 s, a voxel size of 0.18 mm, and a field of view (FOV) of 8cmx8cm or 10cmx10cm or 10cmx5cm. CBCT software (CS 3D imaging) was used to study these scans. The included scans were from patients between 12 and 75 years of age. In each CBCT scan, both right and left maxillary first molars were studied. The maxillary first molars with complete root formation were included in the study. Tooth with evidence of prior root canal treatment (including the presence of root canal fillings or post), root resection, or periapical surgery, rehabilitation by means of fixed prosthesis were excluded. According to this criterion, a total of 600 maxillary first molar were included in the study. Out of the 600 maxillary first molars, 598 were three rooted whereas 2 were two rooted molars. These 598 three rooted molars were evaluated for the prevalence and location of MB2 canal.

The axial axis of each of these 598 three rooted maxillary first molars was first corrected on the sagittal plane. The floor of the pulp chamber was then located (Fig. 1A and B), and advanced apically by 2 mm to standardize observation of the MB2 canal (Fig. 2A). The presence or absence of MB2 canal was then noted in the axial view [Fig. 2B]. When MB2 was present, the geometric position of MB2 canal was studied in axial section according to the protocol described by Gorduysus et al.[8] and Betancourt et al.[9] The center points of first mesiobuccal canal (MB1), palatal canals (P) and second mesiobuccal canal (MB2) were located and straight lines were drawn connecting these points (MB1-MB2, MB1-P). Another line, MB2- T, was drawn from MB2 perpendicular to MB1- P line (T point). The distances between the points on the drawn line were measured in millimeters (Fig. 3). The data was correlated with age, gender and side.

3. Statistical analysis

The data were analysed using SPSS Version 23.0 (IBM,Chicago) software. Chi square test was used to determine the relationship among the sex, tooth position and age on the prevalence of MB2 canal in maxillary first molar. A p value of < 0.05 was considered statistically significant.

4. Results

The prevalence of MB2 canal in three rooted maxillary first molar was 61.9%. The average age of the patients whose scans were evaluated was 33.9 ± 13.9 years. It was seen that the prevalence of MB2 was highest in 20–40years age group (67.4%) followed by > 40 years (57.5%) and lowest in < 20 years (50.6%). The difference in the prevalence distribution among different age groups was statistically significant ($p = 0.005$, Table 1). No statistical significance was found in the prevalence based on tooth position ($p = 0.92$) or gender ($p = 0.77$). The prevalence of MB2 canal in three rooted maxillary first molar by tooth position and gender is presented in Table 2.

Analysed with 95% confidence interval, at 2 mm from the floor of pulp chamber, the distance between midpoints of MB1 and MB2 canal (MB1-MB2) was 2.5 mm ± 0.6 mm (Range 1.1–4.1 mm). The average distance between midpoints of MB1 and palatal canal (MB1-P) was 7.3 ± 0.8 mm (Range 5.6–9.1 mm) and for line extending from midpoint of MB2 perpendicular to line joining MB1- Palatal canal (MB2-T) was 1.0 ± 0.4 mm (Range 0–1.8 mm).

5. Discussion

Failure to locate and treat all the canals may lead to unfavourable treatment outcome.[3,4,10] One of the commonly missed canal during root canal treatment is the second mesiobuccal canal in the maxillary first molar.[3] Leaving this canal untreated may allow microorganisms to colonize the space, leading to infection and treatment failure.[8,11] A retrospective CBCT study on Indian population concluded that 72.7% of unfilled MB2 canals in endodontically treated maxillary first molars showed significant periapical radiolucencies.[12] Therefore, it is of utmost importance to use additional aids like dental operating microscope, ultrasonics and even CBCT to detect the second mesiobuccal canal.

The present study describes thorough and comprehensive information on the prevalence of second mesiobuccal canal in three rooted maxillary first molars of Indian population using CBCT. Patel et al.[13] and Blattner et al.[14] found CBCT to be a highly accurate, non invasive three dimensional tool to detect the presence of MB2. Our study

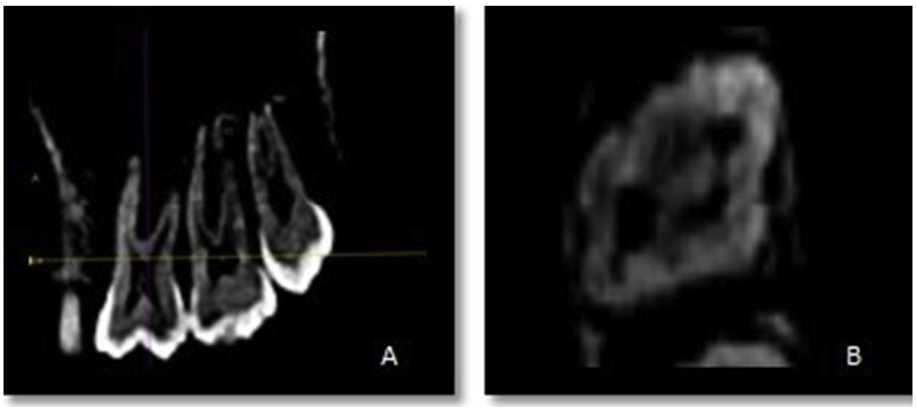

Fig. 1. CBCT image of the mesiobuccal root of maxillary first molar at the level of floor of pulp chamber. A: Sagittal view; B: Axial view.

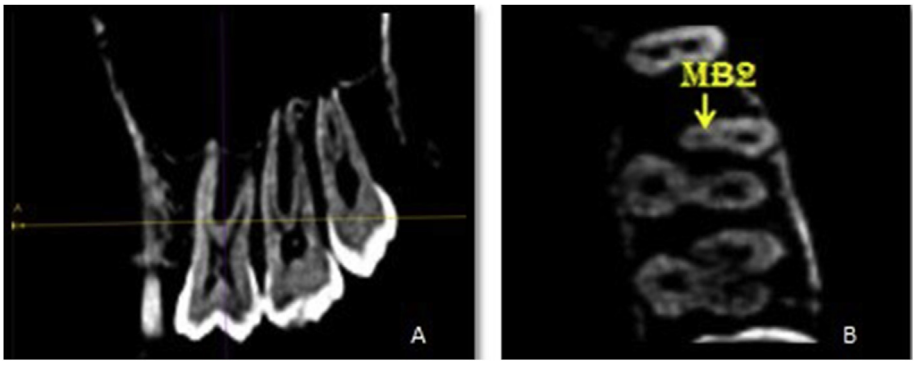

Fig. 2. CBCT image of a maxillary first molar with two canals in the mesiobuccal root at 2 mm apical to the floor of pulp chamber. A: Sagittal view; B: Axial view. Arrow- MB2 orifice.

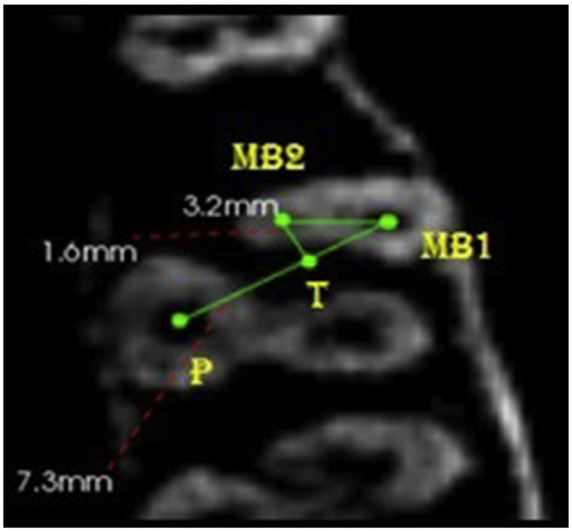

Fig. 3. Axial view of maxillary first molar. Points MB1 (center of MB1 canal), MB2 (center of MB2 canal) and P (center of palatal canal) were marked. Straight lines were drawn connecting points MB1 and MB2 (MB1-MB2 line), MB1 and P (MB1-P line). A third line, MB2- T, was drawn corresponding to a perpendicular line between MB2 and the MB1-P line (T point).

Table 1
Frequency of MB2 by age range.

Age wise prevalence of MB2 canal with respect to the total no. of teeth examined among study participants using Chi Square test (n = 598)

MB2	< 20 yrs [n = 89]		20–40 yrs [n = 328]		> 40 yrs [n = 181]		x^2 Value	P-Value
	n	%	N	%	N	%		
Absent	44	49.4%	107	32.6%	77	42.5%	10.536	0.005*
Present	45	50.6%	221	67.4%	104	57.5%		

*p < 0.05 - Statistically Significant.

Table 2
Number and frequency of MB2 canal in mesiobuccal root of maxillary first molar by tooth position and gender.

MAXILLARY FIRST MOLAR (3 rooted) n = 598	TOOTH POSITION		GENDER	
	RIGHT	LEFT	MALES	FEMALES
NUMBER OF TEETH	185/298	185/300	226/368	144/230
FREQUENCY (%) OF MB2 CANAL	62.08	61.67	61.41	62.61
p VALUE	0.92		0.77	

*p < 0.05 - Statistically Significant.

reported higher prevalence as compared to other CBCT studies performed earlier on Chinese and Korean population; but lesser prevalence as compared to North American population.[15–17] Cleghorn et al., in 2006 performed a systematic review on the anatomy of the permanent maxillary first molar through a meta analysis of data of about 8399 teeth from 34 laboratory studies and of 2576 teeth from 14 clinical studies. They reported that the incidence of two canals in the mesiobuccal root was 56.8%[18] which is similar to that obtained in our study.

Prior studies using CBCT on Indian population have showed wide differences in prevalence. These differences can be explained by variations in subpopulation group studied, sample size, study design, author's definition of what constitutes a canal and the average age of the population studied.[4] Neelakantan P et al.[19] and Karunakar et al.[20] have reported prevalence of MB2 in maxillary first molars in Indian population to be 44.1% and 47.1%, respectively. The prevalence obtained in our study was 61.9%. This higher prevalence in our study can be attributed to a larger sample size and differences in the average age of the population. However, our results regarding the prevalence of MB2 canal are lower than the results of Kashyap RR[21] et al. who found MB2 canal in 76.5% of maxillary first molars using CBCT. This can be due to difference in study methodology. In our study, the prevalence was checked at 2 mm below orifice level whereas Kashyap RR[21] et al. evaluated the entire length of mesiobuccal root to detect additional canals. Other contributing factor include difference in sample size and difference in average age of the population studied. Previously mentioned CBCT studies on Indian population were carried out in sample size of 75,[21] 100[20] and 220[19] maxillary first molars, hence our study intended to expand this study sample to 598 maxillary first molars. Studies using tooth clearing and dye penetration method to detect MB2 canal in South Indian population revealed a prevalence of 31%[22] and 84%.[23]

Our study standardized the MB2 canal observation to 2 mm apical to floor of pulp chamber. This standardization was necessary as, in clinical situations, there is frequently a ledge of dentin of about 2 mm that covers the MB2 orifice.[8,11] Also, MB2 canals may have one or more abrupt curvature in the coronal portion of the root[24] and may often arise at a considerable mesiobuccal angle from the floor of pulp chamber.[25] For these reasons, it may be necessary to remove about 0.5–3 mm of dentin to uncover these orifices completely with the help of ultrasonic tips under magnification.[1,8] According to Spagnuolo et al.[7] the mean vertical distance between the MB1 and MB2 planes was 1.68 ± 0.83 mm. Hence, 2 mm apical to floor of pulp chamber was selected to standardize the identification and location of MB2 canal.

No statistical significance was seen in inter-gender comparison and side. This was consistent with other CBCT studies done on Indian population.[19,20] MB2 canal tends to appear bilaterally, which is similar to that reported by Kashyap RR,[21] in Indian population. This emphasizes that when MB2 exists on one side, the clinician must consider searching for MB2 on the contralateral side. Results of chi-square indicated

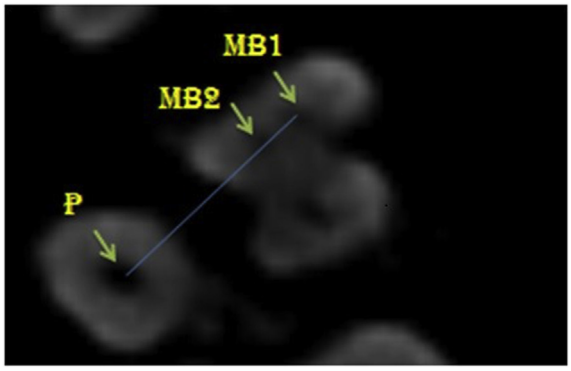

Fig. 4. MB2 canal present on the line joining the MB1and Palatal (P) canal.

statistical significant interaction between age groups. The age group < 20 years(50.6%) and > 40 years(57.5%) showed less prevalence compared to 20–40 years(67.4%). The low prevalence in < 20year age group can be attributed to presence of single wide mesiobuccal orifice. As person ages, a septum of secondary dentin is formed that divides the single wide orifice into two separate orifices. Hence, in young individuals, these canals are regarded as 'ribbon shaped' canal, rather than two canals. In > 40 years age group, decreased prevalence was observed in our study. It may be due to the fact that in this age group many MB2 canals were not seen at 2 mm level but were present at more apical levels and hence were not included in the prevalence. This was consistent with the findings of Reis et al.[26] and Lee et al.[27] who also found reduced prevalence. Another reason for low identification of MB2 canal in older age group in Indian subpopulation may be due to increase in chances of osteoporosis and bone loss which results in decreased radiodensity and thereby decreased contrast with the MB2 canal.[28,29] Therefore, the importance of age in the detection of MB2 canals cannot be undermined and the prevalence of MB2 differs in various studies carried out in similar population, due to the average age of the population taken into consideration. Also, these findings suggest that in patients within the 20–40years age group, additional attention must always be made in identifying and locating MB2 canal by troughing under magnification. However, in > 40 years patients, the vertical inter-orificial distance between the mesiobuccal canals increases due to coronal calcification of the narrow MB2 canal. In these patients, attempts to locate the canal must be restricted to about 3 mm of careful troughing and not beyond as the chances of furcal perforation increases at greater depth.[1]

At 2 mm from the floor of pulp chamber, the average distance between MB1-MB2 was 2.5 mm ± 0.6 mm (Range 1.1–4.1 mm), MB1 and P was 7.3 ± 0.8 mm (Range 5.6–9.1 mm) and MB2-PT was 1.0 ± 0.4 mm (Range 0–1.8 mm), that is, MB2 canal is located about 2.5 mm palatally and 1.0 mm mesially to MB1 canal. In almost all maxillary first molars, the MB2 was located mesiopalatally except in two teeth in which it was located on the line joining the MB1 and palatal canals. (Fig. 4). Gorduysus et al. reported MB2 location 1.65 ± 0.72 mm palatally and 0.69 ± 0.42 mesially,[8] in contrast to our study which reported 2.5 mm ± 0.6 mm palatally and 1.0 ± 0.4 mm mesially. In a study done by Gordysus et al. both maxillary first and second molars were evaluated,[8] whereas our study included only maxillary first molars which might account for difference in results. Another reason is that the use of dental operating microscope with different magnifications distorts the images, whereas with CBCT, the voxel is isotropic resulting in an image which is free of distortion or magnification (1:1). Our results regarding the location of the MB2 canal are higher than Degerness & Bowles,[30] who located the MB2 canal mesially to the MB1 canal (MB1-MB2) at a distance of 1.78 ± 0.6 mm using a stereomicroscope and Gilles & Reader,[31] who located 2.06 mm through scanning electronic microscopy. This could be explained by the increased sensitivity in in-vitro studies. This is one of the first studies on location of MB2 in relation to MB1 and palatal canal in maxillary first molar in Indian subpopulation. More studies using different methods need to be carried out to confirm these results and to note the variations between different populations.

Troughing must be carried out mesiopalatally and apically along the mesiobuccal pulpal groove with a distinct mesial orientation under magnification for locating MB2 canal using ultrasonics[1,8,25] or with burs- Munce, Moller burs, ¼, ½, #1, #2 round burs.[1,8] This transforms the access cavity from triangular to rhomboidal shape with the four orifices making the four corners of the rhomboid.

The results of this study indicate that CBCT is a non-invasive, effective and high-accuracy diagnostic tool for detecting and locating MB2 canal in-vivo in the mesiobuccal root of maxillary first molar,[13,14] thereby increasing the chances of endodontic success. Using CBCT, the root and canal morphology of maxillary molars can be understood in the diagnostic stage which helps the clinician to perform the endodontic treatment effectively, safely and predictively.

6. Conclusion

Given the anatomical complexity of the mesiobuccal root and the high frequency of the MB2 canal, the clinician must always assume the existence of two canals in this root. In this study, the prevalence of MB2 canal in maxillary first molar of an Indian population was 61.9%. MB2 canal is located mesiopalatally; 2.5 mm palatally from MB1 and 1.0 mm mesially with respect to the line joining MB1 and palatal canals. Hence, shape of access cavity should be modified from triangular to a rhomboid shape. Troughing mesiopalatally (about 2.5 mm palatally and 1 mm mesially) from MB1 to a depth of about 2 mm from the floor of pulp chamber may be necessary for locating MB2 canal with the help of dental operating microscope and ultrasonics.

Conflicts of interest

The authors declare no conflict of interests.

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Authors' contributions

All authors contributed to the work.

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